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Decision Conferencing on Countermeasures after a Large Nuclear Accident

Report of an Exercise by the BER-3 of the NKS BER Programme

Simon French, Ole Walmod-Larsen and Kari Sinkko

Risø National Laboratory, Roskilde, Denmark
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Report of an Exercise by the BER-3 of the NKS BER Programme

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January 1993

Abstract The BER-3 Project of the emergency preparedness programme (BER) of the Nordic Co-operation Organisation (NKS) organised a decision conference to address the following objectives.

1. To achieve a common understanding between decision makers and local government officials on the one hand and the radiation protection community on the other of the issues that arise in decisions in the aftermath of a major nuclear accident.
2. To identify issues which need to be considered in preparing guidance on intervention levels.
3. To explore the use of decision conferencing as a format for major decision making.

To achieve these objectives the participants were invited to consider a scenario of a hypothetical radiation accident. The scenario assumed that appropriate early protective actions (sheltering, issuing of iodine tablets, etc.) had been taken and that the conference was meeting some eight days into the accident to consider medium and longer term protective actions, particularly the need for relocation of certain areas. By the end of the conference, considerable consensus on the general form of the strategy had emerged. Moreover, there was a better understanding of the evaluation criteria against which such a strategy needed to be developed.

Many felt that it was important to retain flexibility in the strategy of protective actions, even if this increased the uncertainty for the affected population, who would not know exactly what would be done for several months. This emphasised even more the need for good communication and understandable presentations of the adopted strategy. All felt that more research and advice is needed on the psychological effects of such accidents and the effects of protective actions. It was felt that the exercise had illustrated the problems inherent in radiation emergencies. However, a different situation with larger populations could have led to different results.

It was agreed that the exercise had been useful in meeting the need to think about the issues before an accident happens. On the general matter of intervention levels, it was suggested that guidance should not constrain the authorities into doing something which might not be appropriate to the particular circumstances of an accident. It needed to recognise, for instance, that one can evacuate small numbers of people but not large cities.

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1 Introduction

The BER-3 Project of the emergency preparedness programme (BER) of the Nordic Co-operation Organisation (NKS) Programme organised a *decision conference*[1] on December 8th-9th, 1992 at the Civil Defence High School at Snekkersten, Denmark. The objectives of the conference were threefold:

1. To achieve a common understanding between decision makers and local government officials on the one hand and the radiation protection community on the other of the issues that arise in decisions in the aftermath of a major nuclear accident.
2. To identify issues which need to be considered in preparing guidance on intervention levels.
3. To explore the use of decision conferencing as a format for major decision making.

To achieve these objectives several local government officials, emergency planners and members of the radiation protection community in the Nordic countries (A list of participants is given at Annex 1) were invited to consider a scenario of a hypothetical radiation accident. This was developed from one in the BER-3.2 Report. The accident was assumed to have happened on December 1st, 1992 and had left the North of the island of Gotland significantly contaminated, caused by a heavy snowfall during the plume passage. Appropriate early protective actions (sheltering, issuing of iodine tablets, etc.) had been taken, and the conference met eight days into the accident to consider medium and longer term protective actions, particularly the need for relocation of certain areas. Every participant had been circulated with a brief description of the first three days of the accident beforehand: see Annex 2. Some - the technical experts who in reality would be much more closely in touch with the detailed situation - were sent a more technical briefing just before the meeting: see Annex 3.

It was realised from the outset that total realism could not be obtained, and many flaws with the form of the exercise and the scenario were noted both before and during the conference. Clearly no papers circulated beforehand could simulate the level of knowledge that each participant would have had in a true emergency. The data were lacking in many respects, particularly in relation to the level of uncertainty that might be expected on some of the measurements and the distributions of dose in both space and time. The response of the public and the media to the emergency had not been simulated in any respect. The conference involved rather more people than would have taken part in a single country's emergency response. Also technical support would have been far greater in practice, with many more modelling and dose prediction programmes available. Because of its exploratory nature, several decisions were taken during the conference to limit the discussion to a few possible relocation strategies, to take on trust certain estimates of cost, to assume that most of the public would adopt the advice given by officials, etc. None the less, within these limitations the participants entered into the conference willingly and gave valuable and realistic opinions and judgements as required. The BER-3 and the conference organisers are grateful to them all for the spirit and the enthusiasm that they showed.

Confidentiality was discussed at the outset. It was agreed that a decision would be made at the end of the conference on what might be reported more widely, but until then all discussion would be confidential. At the end of the second day, all participants agreed that the discussion and the models could be reported, subject to the points made in the preceding paragraph being noted: namely, that no exercise could simulate reality perfectly and that their deliberations had been limited by lack of certain data, etc.

The report is organised as follows. The early sections focus on the discussion and conclusions drawn and thus address the first two objectives of the conference. The concluding section reflects on the nature of decision conferencing and its success or otherwise as a format for running such meetings.

[1] Briefly a decision conference is a two or three day meeting in which a group of decision makers gather to consider major strategic issues. The distinguishing feature of a decision conference is that the decision makers are suppoorted in their deliberation by a *facilitator* and an *analyst*, who do not contribute to the content of the discussion but rather focus their attention on the decision making process, helping the decision makers achieve a shared understanding through the use of decision modelling. Further details are given in Section 6.

2 Concerns and Issues

The conference began with a wide-ranging debate of many of the issues and concerns that the scenario stimulated.

- The word 'acceptable' was used on many occasions: e.g. acceptable risk. Some felt 'tolerable' was a more appropriate word to use in most, if not all circumstances. All felt that what was acceptable or tolerable was to be the subject of the two days' discussion.
- The question of budget was raised. Would the cost of protective actions be a limiting factor? It was felt that the limited scale of the accident would mean that money would be made available for all the protective actions that might be considered and that total cost would not be a constraint, although 'value for money' issues would be of concern. It was pointed out that, had the accident led to parts of Copenhagen being contaminated, the costs would have been far greater due to the greater density of population and total cost would have been a serious issue.
- Time scales: how far into the future should protective actions be planned? Some felt that strategies should look to the next few weeks without making longer term commitments. It was felt strongly by the decision makers that flexibility would be an important attribute of the strategies. Waiting for the snow to melt and determining actual rather than predicted contamination was felt to be important. However, others felt that, firstly, predictions of contamination would be relatively accurate: there was much experience in Scandinavia of predicting contamination after the melting of snow. Secondly, and more importantly to them, the public would be concerned if the protective actions' strategy left too many uncertainties. People would want to know how long they were being evacuated and whether permanent relocation was necessary.
- It was agreed that if any evacuation[2] was for longer than a year, this should be looked upon as permanent relocation.
- Issues related to psychological stress, social and political acceptability and public confidence were discussed many times in the conference. It was acknowledged that psychological stress could lead to health effects of a comparable nature to those arising from the contamination and at the same time reduces the quality of life significantly. Many of the points made in Eränen and Salo (1992) were repeated in the conference.
- All agreed that it was of paramount importance to ensure that communications with the public were clear and that the advice given was both transparent and supported by easily understood reasons. Because of the unanimity on this, the issue of communications was not discussed in detail during the meeting: it was assumed that whatever strategy was adopted, emphasis would be placed on conveying it clearly and understandably to the public.
- There was a need for the short term and longer term protective actions to be consistent. Both for the public to understand the measures and for them to be applied fairly, the different aspects of the strategy must cohere. If public confidence was not maintained, the ability of the authorities to continue to deal with this accident and also to deal with future accidents would be severely reduced. The importance of monitoring the public's attitude towards the authorities handling of events was noted. It was suggested that information on this can be obtained within a week, especially if its collection planned in advance. Thus in a real conference taking place some eight days after an accident it would be possible to have information available on the public's attitudes.
- It was also agreed that no strategy in this scenario would involve compulsion. Only advice, albeit strong advice, would be given by the authorities.
- Once advice had been given the authorities would have to bear the cost of following that advice. Thus in evaluating the strategies, their full cost was assumed to fall on the authorities. It was recognised that in practice cost might be reduced because of non-compliance or because members of the public used their own resources, but no allowance for this was made in the modelling.

[2] The terminology used in the conference is followed in this report. ICRP, for instance, recommend the terminology 'temporary or permanent relocation' for periods in excess of one week.

- It was noted that there would be differences between the compliance with the advice given by young and old families. Those with young children and particularly those who were pregnant would be more likely to relocate. Older families would be more likely to remain whatever the advice. It was also noted that whole families would need to be relocated or evacuated. Moreover, some members of the community would need to relocate if others did: e.g. school teachers, if all the younger families left the region.
- Security would be an issue. If properties were left unoccupied, their security would need maintaining.

3 Development of the Decision Models

During the two days, a sequence of multi-attribute value decision models was built, each refining the perspective brought by the previous one. For a description of the form of such models, see, e.g., French (1986), Lochard, Schneider and French (1992) or Gjørup et al (1992).

The criteria for evaluating possible strategies were discussed upon many occasions. Issues related to social acceptability, psychological stress and the confidence of the population at wide in the authorities were repeatedly considered. The hierarchy of evaluation criteria or attributes given below is that used in the 'final' evaluation on the second afternoon.

Evaluation Criteria

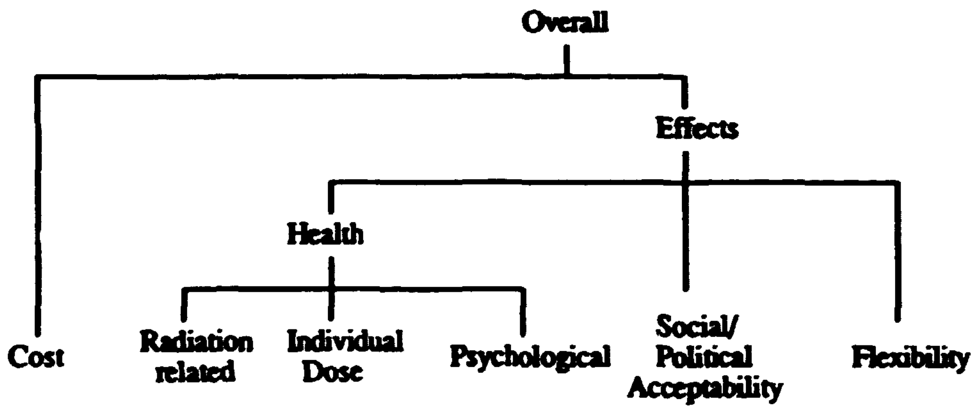

Figure 1: Hierarchy of evaluation criteria used in the final decision model.

The different *evaluation criteria* or *attributes* were defined as follows.

Cost

The cost calculated in MSEK allowing for the cost of relocation per person, the costs of evacuation per person, the cost of lost capital and lost land, and the cost of decontaminating regions.

Health

The effect on health was seen as having three components. The following abreviations were used for these.

Radiation Related Health Effects. Expected number of cancers saved by averting the collective dose, calculated by applying a risk factor of 5% to the dose in manSv (ICRP).

Individual Dose Health Effects. Concerns for the well being of pregnant women and for children as well as for other individuals was expressed through the maximum expected individual dose in the first month if the strategy were applied.

Psychological Health Effects. Loss of quality of life, destruction of social networks, temporary accommodation, radiation fears, increased rates of abortion, voluntary limitation of family size, etc. causing stress, depression, and other clinical effects which might lead to increased morbidity and mortality.

Social/Political Acceptability

Acceptance of the population and agreement that the authorities have dealt with the situation adequately.

Flexibility

Ability of the authorities to react to the evolving situation. In particular, it was felt that leaving certain decisions about decontamination to the Spring would be particularly advantageous.

Strategies

Seven strategies for protecting the population were considered[3] in the early decision models and an eighth was added during the construction of the final models. The eight strategies are defined in the table below in terms of their treatment of areas I, II and III, which were the areas significantly contaminated. It was agreed that all strategies should be advisory: i.e. no member of the public would be compelled to evacuate or whatever. The authorities would merely advise strongly that members of the public should comply with the suggested measures. It was also agreed that the costs of following the advice would have to be borne by the authorities. The terminology adopted was that 'evacuation' was a temporary measure (in this case for six months), during which time property would be kept secure for the population to return to at the end of the period. 'Relocation' was permanent: relocated households would leave their homes and communities for the foreseeable future and begin again elsewhere. Decontamination was interpreted as adopting procedures described by Brown, Heywood and Roed (1992) in their middle category.

Strategy	Relocate indefinitely	Evacuate for 6 months	Decontaminate while evacuated
1	-		-
2	-	I	I
3	-	I,II	I,II
4	-	I,II,III	I,II,III
5	I	-	-
6	I	II	II
7	I	II,III	II,III
8	-	I,II,III	-

Table 1: The Strategies defined in terms of their effects on areas I, II and III

The numbers of people affected by these strategies, the collective doses that would be averted, the maximum individual dose in the first month and the costs are given in Table 2 below. The costs were calculated using the figures given in Annex 3 and also those in Brown et al (1992). Note that it was assumed that decontamination of rural land costed the same as decontamination of urban land: 5 MSEK per km^2.

The decision model was built using the software package HIVIEW (Barclay, 1987). This package allows subjective scales of preference, such as those needed by the evaluation criteria social/political acceptability and psychological health effects, to be assessed and used easily. However, it does require that all scales increase in numerical value with preference: higher numbers always represent more preferred alternatives. Thus in the analyses that follow *higher* scores for costs, for instance, correspond to *cheaper* costs. Moreover, it is more convenient in using the package to normalise all scales to run between a minimum value of 0 and an maximum value of 100. The collective doses averted, the individual doses and the costs given above were transformed

[3] It should be emphasized that had the exercise been 'for real' many more strategies would have been considered. It is likely that in a real analysis the strategies would have been refined in each cycle of model building to capture the insights gained during that cycle. In the exercise it was decided to work with these rough strategies so that attention could be focused on other issues such as the evaluation criteria.

Strategy	No. Relocated	No. Evacuated	Collective dose averted (manSv)	Max. individual dose (mSv)	Cost (MSEK)
1	0	0	0	39	0
2	0	1805	213	23	917
3	0	2795	283	10	1812
4	0	6630	399	3	3562
5	1805	0	731	23	3015
6	1805	990	801	10	3909
7	1805	4825	917	3	5659
8	0	6630	290	3	597

Table 2: The numbers evacuated and relocated, the collective doses averted, the maximum individual doses and the costs of the strategies

linearly to 0-100 scales and their different 'relative lengths' taken account of in the weighting factors described below.

The scales for the other criteria were developed judgementally after much discussion and given the values below.

Psychological Health Effects:

Strategy	1	2	3	4	5	6	7	8
Score	20	60	80	100	0	20	30	50

Strategy 5 was given the lowest score because it relocated area I and thus probably causing considerable stress to the inhabitants there: yet, at the same time it did nothing for the inhabitants of areas II and III, leaving their stress from the concerns about contamination unaddressed. Strategy 4, on the other hand, treated all three areas sympathetically, offering the reassurance of decontamination policies without causing anyone the stress of permanent relocation. The other strategies were set into this scale using similar arguments. Strategy 1, which offered nothing to inhabitants of any area, was the subject of much debate. Its value of 20 was only adopted as a tentative first suggestion. However, since this strategy did not stand out in the final analysis as one the group were inclined to choose, there was no need to refine the value further.

Social/Political Acceptability:

Strategy	1	2	3	4	5	6	7	8
Score	0	100	100	100	60	60	60	30

Strategy 1 was felt to be the least acceptable to the public: the authorities could not be seen to be 'doing nothing'. Strategies 2, 3 and 4 were felt to be equally good in that the protective actions were clearly targeted and, if adopted, both appeared and would be the result of careful deliberation. Similarly, strategies 5, 6, and 7 were equally good although less so that 2, 3 and 4.

Flexibility:

Strategy	1	2	3	4	5	6	7	8
Score	0	70	85	100	0	15	30	100

Strategies 4 and 8 were felt to be equally the most flexible. They allowed some of the decisions concerning decontamination, if any, and return to the area to be left to the Spring: there was an opportunity to reconsider the decision then in the light of events. Strategies 1 and 5 were felt to be the least flexible in that they announced that no action was needed for areas II and III.

There was much discussion concerning the appropriate weights to use in the model. Initially, the weight of the radiation related health effects scale, i.e. the collective dose averted scale, was set to 100. The 'length' of this scale in manSv is 917. The cost scale has a length of 5659 MSEK. Since the recommended alpha value up to 600,000 SEK per manSv would be reasonable and since the model normalises the lengths of all scales to 100, this suggests a weight of (5659/(917*0.6)) = 1000 for the cost scale relative to the averted dose scale. The weights of the other scales were set judgementally. The maximum individual dose scale has a length of (39-3) mSv, i.e. 36 mSv. It was felt that this was three times as important as the maximum collective dose of 917 manSv which might be averted. Thus the weight of the individual dose scale was set at 300. Reducing the psychological effects from their worst level under strategy 5 to their best level under strategy 4 was considered equal in importance to averting a collective dose of 917 manSv, giving a weight to the psychological scale of 100. The social/political acceptability scale was similarly judged to have a weight of 100. In contrast, the difference in flexibility between the best and worst strategies on this the flexibility scale was judge to be only worth half the radiation related health effects scale and accordingly given a weight of 50. Thus the model analysed initially had the weights and scores given in Table 3.

		Strategy							
Criterion	Weight	1	2	3	4	5	6	7	8
Costs	1000	100	83	67	36	46	30	0	89
Radiation related health	100	0	23	30	43	79	87	100	31
Individual dose	300	0	44	80	100	44	80	100	100
Psychological	100	20	60	80	100	0	20	30	50
Social/political acceptability	100	0	100	100	100	60	60	60	30
Flexibility	50	0	70	85	100	0	15	30	100

Table 3: Weights and scores used in the initial analysis

4 Analysis of the Model

Multi-attribute value analysis begins by simply multiplying each score by the appropriate weight and aggregating to give an overall score for each strategy. A simple cost-benefit model comparing the costs of the strategies with the collective dose saved using an alpha value of 600,000 SEK is obtained by setting all weights to zero except for those on costs and radiation related health effects, which are left at 1000 and 100, respectively. Doing this gives a ranking of actions as given in Table 4. It can be seen that strategy 1, that of 'doing nothing' is just optimal. *Note:* The overall scores have been normalised so that a score of 100 on both cost and radiation related health scales would give an overall score or 100.

When all the weights are set to their values in Table 3, i.e. when all criteria are included in the analysis, the overall scores and ranking are as given in Table 5. It can be seen that introducing the other concerns modelled by the evaluation criteria swings the decision away from 'doing nothing' to strategy 8, which protects areas I, II and III by relocation or evacuation, but does not decontaminate any area. The optimality of this strategy arises because of the high cost of decontamination; 5 MSEK per km². Indeed, strategy 8 was introduced into the analysis to confirm this insight.

Strategy	1	2	3	4	5	6	7	8
Overall Score	90	78	64	37	49	36	9	84
Rank	1st	3rd	4th	6th	5th	7th	8th	2nd

Table 4: Overall scores for 'simple cost benefit' analysis.

Strategy	1	2	3	4	5	6	7	8
Overall Score	61	72	71	58	44	44	30	82
Rank	4th	2nd	3rd	5th	6th	6th	8th	1st

Table 5: Overall scores for the initial analysis based upon scores and weights in Table 3

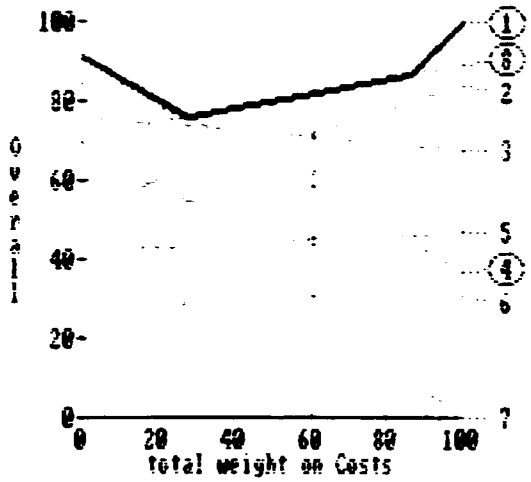

Figure 2: Sensitivity analysis on Costs.

The recommended 'alpha value' of 600,000 SEK was felt by many of the rather low or, equivalently, the weight on Costs was felt to be rather high. A sensitivity analysis on the weight on Costs is shown in Figure 2. Currently the weight on Costs is 1000 which is about 60% of the total weight in the model (1650). The vertical line marks this value. Corresponding to each strategy is a line which plots the overall score for a strategy against the percentage of total weight on Costs. The current optimality of strategy 8 is shown because its plot gives the highest intersection with the vertical line.

As the weight on Costs decreases from 60%, strategy 8 stays optimal until the weight is about 28% when strategy 4 becomes optimal. The change in optimal strategy is indicated by the shading in the sensitivity analysis diagram.

Further insights can be obtained by considering the plot shown in Figure 3. To interpret this figure, remember that increasing scores go with increasing preference. Thus lower costs have higher scores. The figure plots the overall score for all effects excluding cost against cost. Ideally one would like a strategy to be represented by a point in the upper right corner. It can be seen from this diagram that strategies 1, 8 and 4 lie on the upper right boundary (*efficient or Pareto*). Which is optimal depends on the weight put on Costs, which defines the trade-off between Costs and the other effects. Optimality moves from strategy 1 to strategy 8 and then to strategy 4 as the weight on Cost decreases from 100% to 0%: c.f. Figures 2 and 3. Strategies 5, 6 and 7 can clearly never be optimal without considerable changes in their of the scores and weights: strategies 1, 4 and 8 dominate them (i.e. offer a better choice). Strategies 2 and 3 are also dominated by strategies 1, 4 and 8; but far less clearly.

Values of 2 to 2.5 MSEK per manSv had been used on occasions in decisions within the nuclear industry. Obviously,in these decisions there had been other objectives than just monetary cost and dose reduction. It was argued that 'alpha values' are only 'ball park' figure. If 2.5 MSEK per manSv is used as the alpha value, the weight on the costs falls from 1000 to 240 and the overall scores and ranking becomes that given in Table 6.

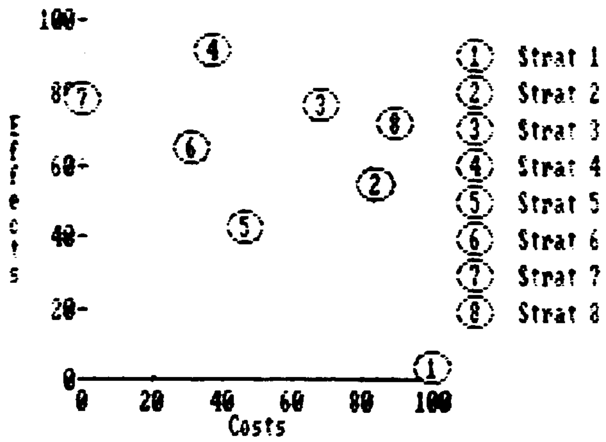

Figure 3: Plot of Effects against Costs.

Strategy	1	2	3	4	5	6	7	8
Overall Score	29	62	74	78	43	55	56	75
Rank	8th	4th	3rd	1st	7th	6th	5th	2nd

Table 6: Overall scores for the analysis when an alpha value of 2.5 MSEK per manSv is used.

Thus the analysis now points to strategy 4 being the best with strategy 8 a very close second. This corresponded closely to the general view of the participants. Indeed, many felt that in practice there would be little difference between the two strategies. Whichever was implemented, decisions concerning areas to be decontaminated and the methods to be employed would be deferred until the Spring. Strategies 4 and 8 simply provided best and worst case estimates of cost and collective dose saved for the course of action that the authorities would be likely to follow.

The above analysis developed over the two days as scores and weights were refined in the light of growing understanding of the issues. Many other sensitivity analyses were carried out, but none cast doubt on the general conclusions reached.

5 Conclusions from the Decision Conference

The decision for a majority of the participants was for a strategy somewhere between 4 and 8. Indeed, many participants felt that in practice there would be little difference between these strategies when implemented, since many subdecisions concerning decontamination and return from evacuation would be deferred until the Spring when more information would be available. Strategies 4 and 8 essentially give best and worse case costings on what would be done, along with upper and lower bounds on the dose averted.

It was also noted that in a conference focused on a real problem more strategies would have been considered. One member felt that evacuating and decontaminating areas I and II as well as selectively decontaminating area III would be a strategy which deserved serious consideration.

Strategy 1, the option of doing nothing, which would be the optimal course of action when averted collective dose and financial cost are the only attributes considered using the Nordic recommended 'alpha' value of 0.6 MSEK/manSv, was the least preferred alternative in the full analysis. It scored badly on every criteria except cost.

Many felt that it was important to retain flexibility in the strategy of protective actions, even if this increased the uncertainty for the population of Gotland which would not know exactly what would be done for several months. This emphasised even more the need for good communication and understandable presentations of the adopted strategy. It was also noted that flexibility would be needed in order to cope with the individual strategies adopted by people on Gotland, who might choose to not to follow the officially advised protective actions.

It was felt that the exercise had illustrated the problems inherent in radiation emergencies. However, a different situation with larger populations could have led to different results. None the less, the evaluation criteria, by and large, would have been appropriate to other situations, albeit with different emphases and weights. They would simply have led to a different choice of protective actions.

The exercise had been useful in that one needs to think about the issues before an accident happens.

All felt that more research and advice is needed on the psychological effects of such accidents and the effects of protective actions.

On the general matter of intervention levels, it was suggested that guidance should be flexible in order not to constrain the authorities into doing something which might not be appropriate to the particular circumstances of an accident. It needed to recognise, for instance, that one can evacuate small numbers of people but not large cities.

6 Reflections on Decision Conferencing

Decision conferencing is a technique – process might be a better word – which seeks to support to a group facing a complex strategic problem. At a decision conference, the group are aided in their discussions by a **facilitator** and, usually, an **analyst**, who attend to the process and decision modelling, leaving the group free to concentrate on the content of their problem. Neither the facilitator nor the analyst are expert in the decision problem facing the decision makers. They assist the conference by keeping the discussion focused on the problem in hand, and ensuring that all present both contribute their views and fully understand the points made by the other decision makers, helping create a shared understanding of both the problem and the way forward.

The facilitator and analyst build decision models of the choice facing the group, projecting the results on a large screen for all the group to see. Typically a sequence of models is built, each a revision or development of the previous, to pace with the group's evolving view of the problem. The modelling invariably leads to much discussion within the group. During the sensitivity analysis phase the results of the model are examined using a wide range of numerical values for the judgements upon which the group cannot agree. Often the final ranking of alternative strategies is unchanged or insignificantly affected by variations across the whole range of numerical values proposed by members. In some cases, of course, significant changes in the ranking do occur and the group must discuss the values further.

French (1992) argues:

»The choice of intervention levels and other countermeasures following a nuclear accident is not simply a technical problem. Political, social, economic and other non-tangible issues are inevitably involved. Decision conferencing is a technique which gathers together all important parties to the decision making for a two day meeting at which all relevant concerns can be discussed and possible protection strategies evaluated. The process is supported by the use of interactive software through which multi-attribute and other decision models may be built to help the decision makers explore the issues. Typically, decision conferences are creative events, constructing strategies as well as evaluating them.«

The meeting reported here is clearly a test of that claim: and, indeed, the third objective of the meeting was to explore the potential of decision conferencing in such circumstances.

During the concluding discussion several points were made which are relevant to this issue.

- All had felt that having many varied perspectives present in the meeting have been useful. It had contributed to a fuller and shared understanding of the problems likely to be faced in the event of a major nuclear accident.
- Most felt that the software had been useful. Its graphical, visual display of sensitivity analyses had helped focus discussion. Some commented that they already use projected computer output in their meetings and the extensive use of such during a decision conference was a natural progression from this.
- There was a suggestion that the meeting would have progressed faster if the evaluation criteria had been defined more fully earlier. However, that may be a comment made with hindsight. It is commonly found in decision conferences that one repeatedly revisits the definition of the criteria during the two days as understanding of the issues evolves. Such an iterative, evolutionary process seems almost inevitable. Ab initio definition of criteria is very difficult.
- Because of the nature of the exercise, the set of strategies was kept more or less fixed during the conference. If the conference had been for real, the set of strategies would undoubtedly have evolved as understanding of the issues, cost and effects grew. It is worth noting here that the introduction of strategy 8 occurred because the relative expense of decontamination became apparent during the analysis of a preliminary model.
- Much more technical support would have been available in a real conference. For instance, when a new strategy was suggested, there would have been manpower available to cost it and to predict its effect in terms of averted dose and maximum individual dose. This would have meant that discussion might have developed faster and in a more focused manner than it did at the meeting.
- There was a feeling that the meeting was too large at nearly thirty participants. Much of the reason for its size was to ensure adequate

representation of the five Nordic countries. Certainly in real circumstances, a decision conference would be smaller, and the grouping more tightly focused on the issues deriving from real circumstances. So perhaps this would not have been a problem in a real conference.

- One participant suggested that whether or not decision conferencing would be a useful tool in the event of a real emergency, it was clearly a useful tool in stimulating discussion in planning and emergency preparedness, as it had been at this conference.

7 Acknowledgements

The BER-3 group are grateful to the participants for taking part in the event fully and giving their advice and judgements freely. They are grateful for permission to report discussion and conclusions from the conference.

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Annex 1: Participants

The following participated at the decision conference:

DK

Knud Bork Kristoffersen,
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H. P. Ryder,
Civilforsvarsstyrelsen,
Kåre Ulbak,
Statens Institut for Strålehygiejne,
Kasper Vilstrup,
Vilstrup Research, BER-3,
Ole Walmod-Larsen,
Risø, BER-3,
Henny Frederiksen,
BER-3 (secretary),

S

Gunnar Bengtsson,
Statens Strålskyddsinstitutt,
Jack Valentin,
Statens Strålskyddsinstitutt,
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Carl Axel Hermansson,
Försvarsdept.,
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Sigurður Magnusson,
SIS, Reykjavik,

GB

Simon French,
Leeds University (facilitator).

Annex 2: Summary of Scenario

Several days before the conference, all participants were sent the following scenario, which had been developed for the purpose by Kari Sinkko and Ole Walmod-Larsen assisted by Anneli Salo, all of the BER-3 Project. Plume dispersion and dose predictions were calculated by Jukka Rossi, Technical Research Centre of Finland using the software package ARANO.

Scenario for the Nordic Seminar Decision Conference Dec. 8-9th 1992, DK

It is a difficult task to make a scenario relevant to all participants coming from almost all corners of Scandinavia. We suggest however the following:

A serious reactor accident has happened in Lithuania at a site around five hundred kilometres east of the island of GOTLAND.

It could have been: KIRKENES or ÅLAND or HEYMAY or BORNHOLM or LÆSØ or ...

- Anyhow it is within YOUR area of responsibility!!

In the morning on Tuesday Dec. 1st. information was received from Lithuania, at the contact point pursuant to the convention on early notification, that a serious accident had happened at 2 o'clock in the morning at the RBMK REACTOR STATION, unit 1. As a consequence of the accident a large release of radioactivity had taken place.

In the following days contact points received an increasing flow of details about the accident from Lithuania. A still unknown amount of fuel in the unit 1 reactor had been overheated resulting in **a sudden, large release of fresh fission products to the atmosphere.**

Of still unknown reasons, several fuel channels had probably ruptured simultaneously and the massive concrete slab above the reactor had lifted. As all the fuel channels are fitted to this slab it can be expected that most of them have been damaged. For the same reason, the majority of the control rods failed to function. Due to the fact that the slab went back into its position, the release was however limited and it was further possible to supply some cooling and to limit and later extinguish a graphite fire.

The weather in the area from Lithuania to Gotland Tuesday night and Wednesday morning was stable with steady winds from the east.

In the Gotland area at noon time Wednesday a **front passage from the west made the weather unstable with showers of rain and later heavy showers of wet snow.** Thursday and Friday falling temperatures and decreasing winds from the west were prevailing in the Gotland area. The mainland had - and still has - stable conditions with clear sky and weak winds from the west.

Based on the weather forecast the flight monitoring team was sent east and southeast of Gotland over the Baltic sea on Wednesday morning.

The preliminary dose predictions and the observation of the plume by the flight monitoring team on SE of Gotland made it clear that the inhabitants of the island had to be warned and iodine tablets distributed. People were also advised to listen to the radio and follow the orders to be given by the authorities.

No deterministic effects were predicted.

A few hours later the monitoring team on the east coast reported a rise in the outdoor dose rate from the ca. 80 nSv/h background to 50 μSv/h.

This confirmed for the experts that **a plume had arrived** and, as they were aware of the possibility of high inhalation doses, they gave advice of sheltering the population of the entire Gotland.

Immediately, at 1430 Wednesday, the Gotland authority decided upon

Sheltering and Intake of Iodine Tablets

for the whole population of Gotland.

Gotland's total number of inhabitants is 56 000. Approx. 21 000 are living in Visby and the number of pregnant women is estimated at 550.

Further monitoring teams and a high ranking expert were dispatched to the island by helicopters to advise the local authorities, take on-the-spot measurements and collect samples for analysis.

Monitoring teams were also put on guard along the mainland coastline towards Gotland. All on-line monitoring stations in the region report normal conditions.

Wednesday at 1800 a meteorological station on the North end of Gotland reported a layer of 3 cm ice covered by 10 - 20 cm of snow, clear sky, decreasing wind towards E and temperatures falling below -10°C.

Thursday morning the experts described the situation as follows: The heavy rain/snow over the upper part of Gotland had caused a substantial wet deposition of fresh fission products during a plume passage in the afternoon hours of Wednesday.

The plume had obviously passed the island from SE, then turned north meeting the showers over the northern end and then returned towards the east, leaving a deposition of radioactivity north of a line ca. 10 km North of Visby city going towards SE.

North of this line the outdoor dose rate levels at 1 m above ground were around 60-70 μSv/h increasing to 400 μSv/h 30 km NE of Visby and further to 2 - 3 mSv/h at the northern end of Gotland.

40 μSv/h was reported from the airport a few km north of Visby.

Towards the south from Visby levels rapidly decreased. 50 km south of Visby was measured 3 times background.

The preliminary sample analyses pointed at a similar pattern in the Cs-137 levels of deposition.

In the southern part levels of few kBq/m^2 were seen. North of Visby was found 50 kBq/m^2. Towards NE these levels grew: 30 km NE of Visby: 0.3 MBq/m^2. Towards Fårö Sound was found several MBq/m^2, and a maximum was measured in a sample from the centre of Fårö island.

Thursday afternoon the telecommunication system of Gotland became overloaded. This lasted till Friday morning. In this period the on-line monitoring station in Visby did not report. Back on-line it showed 30 μSv/h.

After the situation briefing Thursday morning the experts came to the conclusion that **the plume had left Gotland Wednesday night. Therefore the sheltering action should be relieved immediately for the whole island.**

It was judged however - although the information available was incomplete - that the doses to be received by the inhabitants of the Fårö island and by the inhabitants living on the main island at the area from Fårö Sound to 5 - 8 km SW of Fårö Sound would become so high that they would have to be evacuated as soon as possible.

At 10 o'clock on Thursday morning the Gotland authority decided to

Relieve the Sheltering for Gotland and Evacuate the Inhabitants in the Above Described Area.

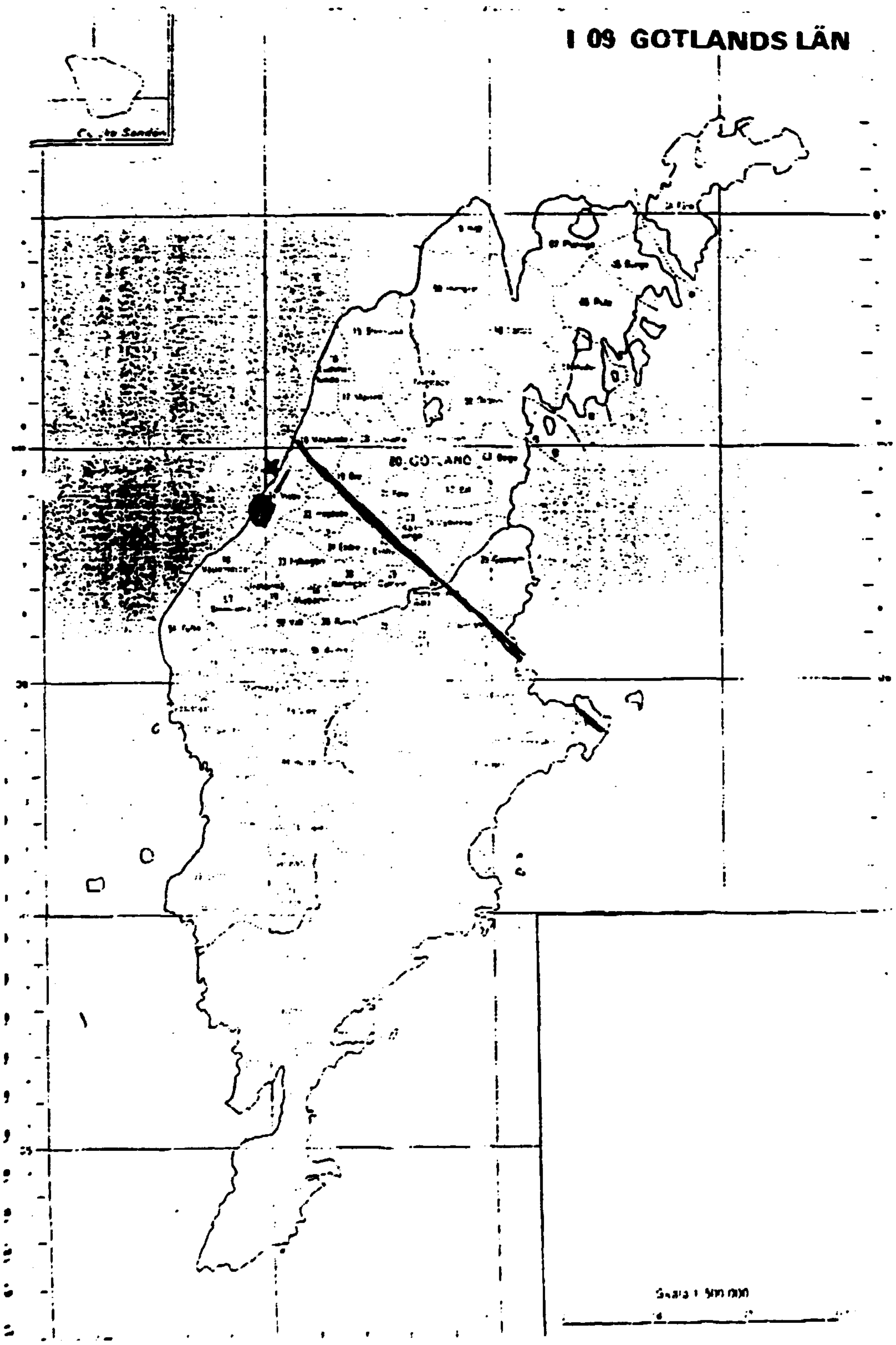

Figure A2.1: Map of Gotland.

Annex 3: Detailed Scenario

The following detailed scenario giving technical data was sent roughly two days before the conference to those participants who would have had such information (albeit in rather larger quantities) in the event of a real accident. These details were available to all participants at the conference.

The Nordic Seminar
Decision Conference Dec. 8 - 9th 1992, CFH, DK

With reference to the letter dated November 27th 1992 hereby further information is given supplement to the scenario described. In the tables below we have gathered all the data which have been measured or predicted and which is assumed to be available at this point of time. The information shown refer to six different fallout areas of Gotland. Their positions can be seen at the attached map.

Radiation Situation

Based upon information received from Lithuania at the contact point, the following fractions of the total core inventory are assumed to have been released to the atmosphere over a period of 12 hours:

Noble gases	all
Iodines	few ten's of percent
Tellurium	few percent
Cesium	few percent
Ba, La, Sr, Ru, etc.	few tenths of percent

The following shielding factors have been assumed to be relevant for Gotland and have been used in the calculations:

	Cloud	Deposition	Inhalation
Wooden houses	0.9	0.3	0.3
Block houses	0.3	0.03	0.3

Table I. Measured average individual doses during the first day (mSv), dose rates on thursday morning (mSv/h), and ^{137}Cs-fallout (MBq/m^2) in various areas of Gotland, see the attached map.

Area	I	II	III	IV	V	VI
Dose for normal conditions (mSv)*	33	20	8.6	2.6	0.86	0.04
Dose when sheltered (mSv)	16	10	4.3	1.3	0.43	0.02
Outdoor dose (mSv)	84	50	22	6.7	2.2	0.1
Dose rate (mSv/h)**	2.5	1.5	0.6	0.2	0.06	0.003
^{137}Cs-fallout (MBq/m^2)	5.0	3.0	1.3	0.4	0.13	0.006

* Normal living conditions, i.e. 10% outdoors and 90% indoors

** Outdoor, Thursday morning

Table II. Predicted average individual and collective doses in the subsequent six days in various areas of Gotland.

Area	I	II	III	IV	V	VI
Dose(mSv)*	47	28	12	3.8	1.2	0.06
Collective* dose(manSv)	85	28	47	8.9	8.6	2.4

* Normal living conditions

Table III. Predicted individual doses (individual effective dose; mSv) for normal living conditions in the six fallout areas considered for various time scales. The dose accumulated during the first week is subtracted.

Area	I	II	III	IV	V	VI
1 Month	39	23	10	3.1	1.0	0.05
6 Months	86	52	22	6.9	2.2	0.10
1 Year	109	65	28	8.7	2.8	0.13
3 Years	151	91	39	12.0	3.9	0.18
10 Years	218	131	57	17.4	5.7	0.26
30 Years	317	190	82	25	8.2	0.38
70 Years	405	243	105	32	10.5	0.49

Table IV. Predicted collective doses (manSv) for normal living conditions in the six fallout areas considered for various time scales. The dose accumulated during the first week is subtracted.

Area	I	II	III	IV	V	VI
1 Month	70	23	38	7.3	7.0	2.0
6 Months	155	51	84	16	15	4.0
1 Year	197	64	107	20	20	5.2
3 Years	273	90	150	28	27	7.2
10 Years	393	130	219	41	40	10
30 Years	572	188	314	59	58	15
70 Years	731	241	403	75	74	20

Table V. Predicted individual ingestion doses (committed effective dose; mSv) to people for different time scales in the six fallout areas considered.

Area	I	II	III	IV	V	VI
1 Year	63	38	16	5.0	1.6	0.08
3 Years	126	76	33	10	3.3	0.15
30 Years	181	108	47	14	4.7	0.22

Milk 300 kg, meat 35 kg, grain 70 kg, green vegetables 40 kg, root vegetables 30 kg per capita is assumed to be consumed in a year. Foodstuffs are assumed to be produced and consumed in the same area.

Taking into account that the fallout area is relatively small we assume that it is feasible to supply uncontaminated food to the entire Gotland.

Monetary Costs of Relocation

Table VI. Assessed monetary costs of relocation (MSEK) in the three fallout areas considered for various time scales.

Area	I	II	III
3 Years	3 800	500	1,700
10 Years	1,300	800	2,600
30 Years	2,100	1,400	4,200
70 Years	3,000	2,200	5,600

Demographic Data

Table VII. The number of inhabitants in various areas considered and the area of the land (km^2).

Area	I	II	III	IV	V	VI
Number of inhabitants	1805	990	3835	2350	7020	40,203
Area	150	160	280	300	580	1,300

Assessment the Monetary Costs of Relocation

Calculation of the monetary costs arising from relocation is largely based on methods presented in the COCO-1 report. The costs of no-action is assumed to be negligible.

Transport Costs:

The transport costs by road for both organised transport using buses and private cars and assuming that the average distance moved is 100 km, is estimated to be 60 SEK/person (running costs of a car per km is 2.5 SEK). The transport costs by boat (ferry) per person is 100 SEK.

Transport costs per journey per person is 160 SEK.

Loss of Income:

It is assumed that if people are relocated, then they will also be unable to reach their workplace and that the contribution they would have made to the economy will be lost. This loss can be assessed from GDP per capita (GDP in Sweden is 160,000 SEK). Note, the loss of income of farmers is included. A mean recovery time of economy around two years is thought to be appropriate as default value.

The loss of income for all relocation strategies per person is 320,000 SEK.

Food and Accommodation Costs:

To avoid double counting the simple approach adopted here is to estimate only the cost of lost accommodation. In choosing the time at which the costing should be stopped to be the same time as the cutoff time for loss of income, two years, and if the GDP used includes the housing component, then accommodation and also food costs are included in costs of lost income.

Costs of Lost Capital Services:

The cost of lost capital services is caused by the acceleration of depreciation due to lack of maintenance and by loss of interest on the original investment. These costs caused by the loss of non-residental capital stock, housing and land are taken into account after the cutoff time, two years, because GDP includes the interest on capital value. Note, the loss of income is calculated for the two first years using the GDP. The GDP does not include consumer durables and therefore the these costs begins at the time of the accident. The rebuilding of industry, public buildings, homes etc is not included as costs, as these costs may be regarded as being equivalent to the costs of the lost capital value of the lost area.

It is assumed that the resettlement process takes one year and that the costs therefore continue for an extra year.

The value of land and its assets for various categories are as follows:

- non-residential capital stock; 150,000 SEK/person,
- housing; 150,000 SEK/person,
- consumer durables; 110,000 SEK/person,
- land:
  - urban areas; 150 MSEK/km^2
  - rural areas; 1.3 MSEK/km^2.

Rates of interest and depreciation:

- interest rate, 5%,
- depreciation rate:
  - stock and dwellings; 5%
  - consumer durables; 10%.

Costs of Lost Capital Services for Various Relocation Strategies (without discounting).

	Capital (MSEK/person)	Urban Land (MSEK/km^2)	Rural Land
3 year	0.11	15	0.13
10 years	0.30	67	0.58
30 years	0.59	217	1.88
70 years	0.69	517	4.50

»Normal« frequences of cancers in Finland in a year

Leukaemia:	Adults:	5-7/100,000
	Children:	5/100,000
	Mortality:	50%
Thyroid:	Adults:	1-2/100,000
	Children:	0.1/100,000
	Mortality:	10%
All others:	Adults:	200/100,000
	Children:	100/100,000
	Mortality:	50%

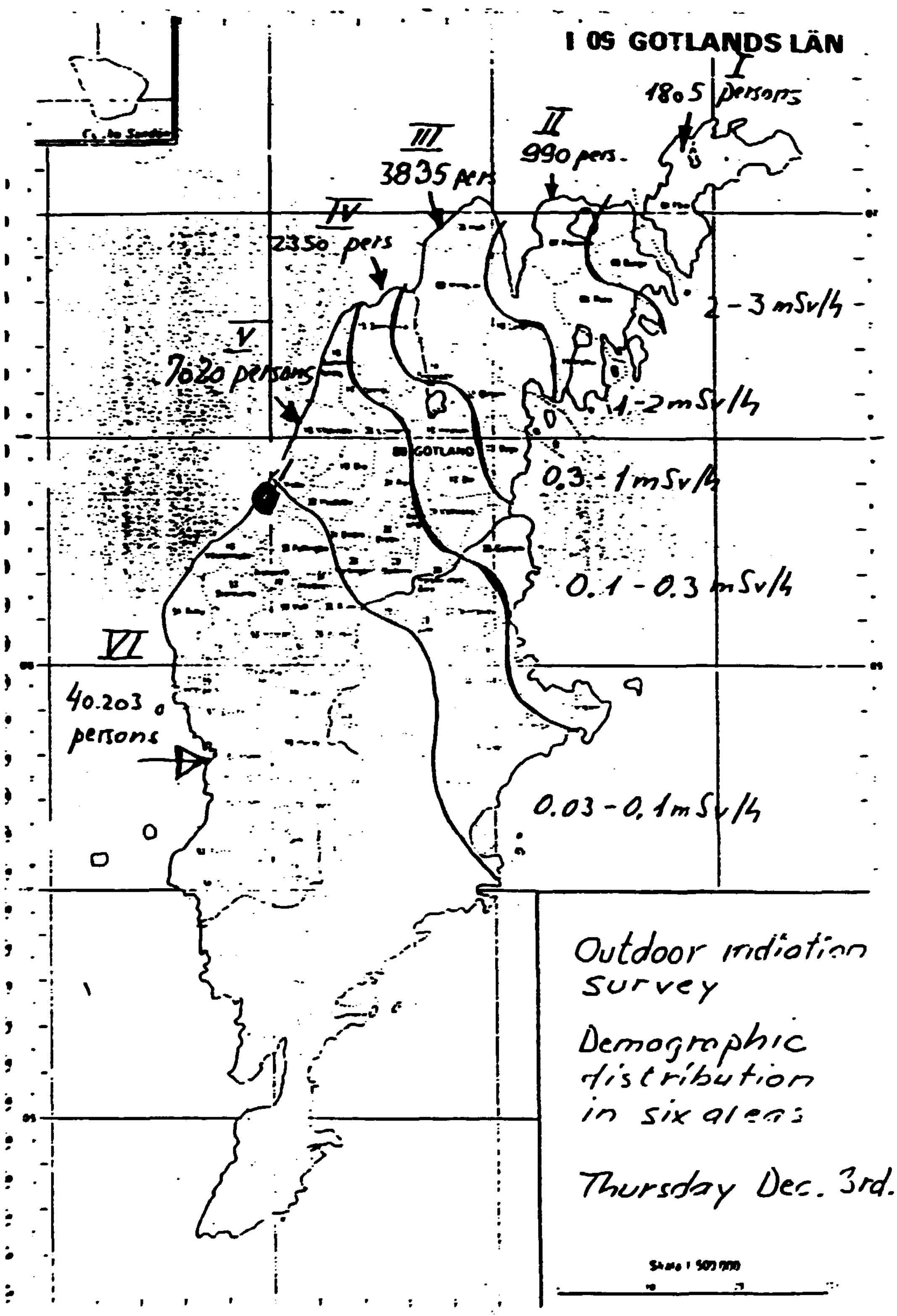

Figure A3.1: Map of Gotland showing distribution of contamination.

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Title and author(s)

Decision Conferencing on Countermeasures after a Large Nuclear Accident
Report of an Exercise by the BER-3 of the NKS BER Programme

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Abstract (Max. 2000 characters)

The BER-3 Project of the emergency preparedness programme (BER) of the Nordic Co-operation Organisation (NKS) organised a decision conference to address the following objectives.

1. To achieve a common understanding between decision makers and local government officials on the one hand and the radiation protection community on the other of the issues that arise in decisions in the aftermath of a major nuclear accident.
2. To identify issues which need to be considered in preparing guidance on intervention levels.
3. To explore the use of decision conferencing as a format for major decision making.

To achieve these objectives the participants were invited to consider a scenario of a hypothetical radiation accident. The scenario assumed that appropriate early protective actions (sheltering, issuing of iodine tablets, etc.) had been taken and that the conference was meeting some eight days into the accident to consider medium and longer term protective actions, particularly the need for relocation of certain areas. By the end of the conference, considerable consensus on the general form of the strategy had emerged. Moreover, there was a better understanding of the evaluation criteria against which such a strategy needed to be developed.

Many felt that it was important to retain flexibility in the strategy of protective actions, even if this increased the uncertainty for the affected population, who would not know exactly what would be done for several months. This emphasised even more the need for good communication and understandable presentations of the adopted strategy. All felt that more research and advice is needed on the psychological effects of such accidents and the effects of protective actions. It was felt that the exercise had illustrated the problems inherent in radiation emergencies. However, a different situation with larger populations could have led to different results.

It was agreed that the exercise had been useful in meeting the need to think about the issues before an accident happens. On the general matter of intervention levels, it was suggested that guidance should not constrain the authorities into doing something which might not be appropriate to the particular circumstances of an accident. It needed to recognise, for instance, that one can evacuate small numbers of people but not large cities.

Descriptors INIS/EDB

DECISION MAKING; EMERGENCY PLANS; PLANNING; POPULATION RELOCATION; REACTOR ACCIDENTS; REMEDIAL ACTION

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